CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Draft Report – Outdoor Lighting Controls

Measure Number: 2016-NR-LTG4-D

Nonresidential Lighting

2016 CALIFORNIA BUILDING ENERGY EFFICIENCY STANDARDS

California Utilities Statewide Codes and Standards Team July 2014

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EXECUTIVE SUMMARY

Introduction

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (CEC) efforts to update California's Building Energy Efficiency Standards (Title 24) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison and Southern California Gas Company – and Los Angeles Department of Water and Power (LADWP) sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to energy efficiency in buildings. This report and the code change proposal presented herein is a part of the effort to develop technical and cost-effectiveness information for proposed regulations on building energy efficient design practices and technologies.

The overall goal of this CASE Report is to propose a code change proposal for measure name. The report contains pertinent information that justifies the code change including:

- Description of the code change proposal, the measure history, and existing standards (Section 2);
- Market analysis, including a description of the market structure for specific technologies, market availability, and how the proposed standard will impact building owners and occupants, builders, and equipment manufacturers, distributers, and sellers (Section 3);
- Methodology and assumptions used in the analyses, energy and electricity demand impacts, cost-effectiveness, and environmental impacts (Section 4);
- Results of energy and electricity demand impacts analysis, Cost-effectiveness Analysis, and environmental impacts analysis (Section 5); and
- Proposed code change language (Section 6).

This is a draft version of the CASE Report. The 2016 Time Dependent Valuation (TDV) values were not yet available when this draft report was being developed. The TDV energy and cost savings presented in this draft report were developed using 2013 TDV values. Despite what the table headings indicate, the TDV energy and cost savings presented in this draft report were developed using 2013 TDV values and TDV cost saving are in 2011 dollars. The Statewide CASE Team will be submitting a revised version of this report in fall 2014, which will include the final recommended code change proposal and a updated TDV energy and cost savings results that use the 2016 TDV values.

Scope of Code Change Proposal

The Outdoor Lighting Controls CASE proposal will affect the following code documents listed in Table 1.

Table 1: Scope of Code Change Proposal

Standards Requirements (see note below)	Compliance Option	Appendix	Modeling Algorithms	Simulation Engine	Forms
M	N/A	N/A	N/A	N/A	TBD

Note: An (M) indicates mandatory requirements, (Ps) Prescriptive, (Pm) Performance.

Measure Description

The Outdoor Lighting Controls measure is intended to modify current code language to make existing controls requirements more streamlined by removing the current exceptions from the controls requirements in Section 130.2(c), for Outdoor Sales Lots and Outdoor Sales Canopies. As a result, newly constructed Outdoor Sales Lot poles under 24 feet and Outdoor Sales Canopy lighting under 24 feet would be required to be controlled by motion sensors or other lighting control systems that automatically reduce lighting power in response to the area being vacated of occupants. The primary impact of these measures will be on gas stations (the most common type of outdoor sales canopy) and auto sales lots (the most common type of outdoor sales lot). Lastly, in response to recent stakeholder input, in future drafts of this CASE proposal the Team will also consider changing the limit currently placed on the allowed wattage reduction during dimming (currently a maximum of 80% reduction).

Outdoor motion based lighting controls were introduced to the 2013 Title 24 Standards for most outdoor lighting area types, but with a number of exceptions in place. The exceptions may have been inserted into the code because these types of multi-level lighting controls installations were rare in sales lots and sales canopies, but in recent years they have started to occur more often, and have received positive reviews from occupants and building owners, so there has been renewed interest in the proposal concept.

Section 2 of this report provides detailed information about the code change proposal including: ***Section 2.2 Summary of Changes to Code Documents (page 4)*** provides a section-by-section description of the proposed changes to the standards, appendices, alternative compliance manual and other documents that will be modified by the proposed code change. See the following tables for an inventory of sections of each document that will be modified:

- Table 5: Scope of Code Change Proposal
- Table 6: Sections of Standards Impacted by Proposed Code Change

Detailed proposed changes to the text of the building efficiency standards, the reference appendices, are given in ***Section 6 Proposed Language*** of this report. This section proposes modifications to language with additions identified with underlined text and deletions identified with ~~struck out~~ text.

Market Analysis and Regulatory Impact Assessment

The market for occupancy-based lighting controls in outdoor lighting design is well-established and many area types, including parking lots and outdoor hardscape. The market for these controls in gas stations and car lots is smaller, but has grown in recent years. This energy savings measure was not being installed to a significant degree several years ago when CEC last set out to update the lighting Standards, so these space types were exempted from these requirements in the 2013 Title 24 code update. It was not clear whether there were technical feasibility concerns or other market barriers, as this type of installation had not been studied and there were few example projects. However, since then, accompanying the rise of light emitting diode fixtures (LEDs), a number of these exempted facilities have begun designing using this approach, both in California and throughout the United States. A similar proposal has also been submitted to the ASHRAE 90.1 Lighting Committee, and there is now momentum and interest in the energy savings potential from bi-level motion controlled lighting in gas stations and car sales lots.

This proposal is cost effective over the period of analysis. Overall, this proposal increases the wealth of the State of California. California consumers and businesses save more money on energy than they do for financing the efficiency measure. As a result this leaves more money available for discretionary and investment purposes.

The expected impacts of the proposed code change on various stakeholders are summarized below:

- **Impact on builders:** The proposed code change is not expected to have an impact on builders.
- **Impact on building designers:** Building designers will need to incorporate control design into the construction of sales canopies and sales lots.
- **Impact on occupational safety and health:** The proposed code change is not expected to have a negative impact on occupational safety and health. It has been suggested because light levels will instantly increase whenever motion is detected on the premises, the measure may in fact increase safety and awareness of occupants and workers in these facilities.
- **Impact on building owners and occupants:** Since this measure is cost effective, the building owners who pay their energy bills are reducing their energy costs more than their mortgage costs are increased as a result of this measure (i.e. they experience net cost savings). For building occupants that are paying for their energy bills, since the measure saves more energy cost on a monthly basis than the measure costs on the mortgage as experienced by the building owner, the pass-through of added mortgage costs into rental costs is less than the energy cost savings experienced by occupants.
- **Impact on equipment retailers (including manufacturers and distributors):** Equipment retailers will need to consider the increased demand for control systems due to this measure.
- **Impact on energy consultants:** Energy consultants will need to consider the new code baseline of lighting equipment in sales lots and sales canopies.
- **Impact on building inspectors:** As compared to the overall code enforcement effort, this measure has negligible impact on the effort required to enforce the building codes.
- **Statewide Employment Impacts:** The proposed code change is not expected to have an impact on Statewide employment.
- **Impacts on the creation or elimination of businesses in California:** The proposed code change is not expected to have an impact on the creation or elimination of businesses in California.

- **Impacts on the potential advantages or disadvantages to California businesses:** The proposed code change can offer energy savings for California businesses.
- **Impacts on the potential increase or decrease of investments in California**: The proposed code change is not expected to have an impact on the increase or decrease of investments in California.
- **Impacts on incentives for innovations in products, materials or processes:** The proposed code change is not expected to have an impact on incentives for innovations in products, materials or processes in California.
- **Impacts on the State General Fund, Special Funds and local government:** The proposed code change is not expected to have an impact on the State General Fund, Special Funds and the local government.
- **Cost of enforcement to State Government and local governments:** The proposed code change is not expected to have an impact on the cost of enforcement to State and local governments.
- **Impacts on migrant workers; persons by age group, race, or religion:** This proposal and all measures adopted by CEC into Title 24, part 6 do not advantage or discriminate in regards to race, religion or age group.
- **Impact on Homeowners (including potential first time home owners):** The proposal does not impact residential buildings. There is no expected negative impact on homeowners; however, the measure may positively affect homeowners by reducing light trespass at night.
- **Impact on Renters:** This proposal is advantageous to renters of gas station and car sales lot facilities, as it reduces the cost of utilities which are typically paid by renters. Since the measure saves more energy cost on a monthly basis than the measure costs on the mortgage as experiences by the landlord, the pass-through of added mortgage costs into rents is less than the energy cost savings experienced by renters.
- **Impact on Commuters:** This proposal and all measures adopted by CEC into Title 24, Part 6 are not expected to have an impact on commuters.

Statewide Energy Impacts

Table 2 shows the estimated energy savings over the first twelve months of implementation of this Outdoor Lighting Controls measure.

Table 2: Estimated First Year Energy Savings

	First Year Statewide Savings			First Year TDV Energy Savings (Million kBTU)
	Electricity Savings (GWh)	Average Power Demand Reduction[1] (MW)	Natural Gas Savings (MMtherms)	
Sales Canopies	1.24	0.31	-	20.4
Outdoor Sales Lots	0.38	0.10	-	6.0
TOTAL	1.62	0.41		26.4

Section 4.6.1 of this report discusses the methodology and Section 5.1.1 shows the results for the per unit energy impact analysis.

Cost-effectiveness

Results of per unit Cost-effectiveness Analyses are presented in Table 3. The TDV Energy Costs Savings are the present-valued energy cost savings over the 15-year period of analysis using CEC's TDV methodology. The Total Incremental Cost represents the incremental initial construction and maintenance costs of the proposed measure relative to existing conditions (current minimally compliant construction practice when there are existing Title 24 Standards). Costs incurred in the future (such as periodic maintenance costs or replacement costs) are discounted by a 3 percent real discount rate, per CEC's LCC Methodology. The Benefit-to-Cost (B/C) Ratio is the incremental TDV Energy Costs Savings divided by the Total Incremental Costs. When the B/C ratio is greater than 1.0, the added cost of the measure is more than offset by the discounted energy cost savings and the measure is deemed to be cost effective. For a detailed description of the Cost-effectiveness Methodology see Section 4.7 of this report.

Because the measure is lighting related and not climate-dependent, cost-effectiveness was not calculated on a per climate zone basis. Rather, cost-effectiveness was calculated for each of the prototype facilities and scenarios modeled.

The Change in Lifecycle Cost values are negative in every prototype facility modeled by the Statewide CASE Team. This means that the proposed code change is cost effective, and the code change will result in cost savings relative to the existing conditions. While the measure is cost effective, the magnitude of cost-effectiveness varies from a high Planning B/C ratio of 2.42 in the auto sales lot prototype facility (with assumed higher wattage fixtures), to a low

[1] Average demand savings does not reflect the maximum demand savings and is not coincident with peak demand. For more detail, refer to Section 4.6.2 of this report.

Planning B/C ratio of 1.06 in the 24-hour sales canopy prototype facility (with assumed lower wattage fixtures).

Table 3: Cost-effectiveness Summary

Prototype	Fixture Wattage	Benefit: TDV Energy Cost Savings (2016 PV $)	Cost: Total Incremental First Cost and Maintenance Cost (2016 PV $)	Change in Lifecycle Cost (2016 PV $)	Planned Benefit-to-Cost (B/C) Ratio
Prototype 1: Large 24-Hr Sales Canopy	122W	$5,966	$3,780	$2,186	1.58
	82W	$4,010	$3,780	$230	1.06
Prototype 2: Large 15-Hr Sales Canopy	122W	$6,110	$3,780	$2,330	1.62
	82W	$4,107	$3,780	$327	1.09
Prototype 3: Small 24-Hr Sales Canopy	122W	$2,652	$1,680	$972	1.58
	82W	$1,782	$1,680	$102	1.06
Prototype 4: Small 15-Hr Sales Canopy	122W	$2,716	$1,680	$1,036	1.62
	82W	$1,825	$1,680	$145	1.09
Prototype 5: Corner 12-Hr Outdoor Sales Lot	202W	$2,540	$1,050	$1,490	2.42
	126W	$1,584	$1,050	$534	1.51

Section 4.7 of this report discusses the methodology and Section 5.2 shows the results of the Cost-effectiveness Analysis.

Greenhouse Gas and Water Related Impacts

For a more detailed and extensive analysis of the possible environmental impacts from the implementation of the proposed measures, please refer to Section 5.3 of this report.

Greenhouse Gas Impacts

Table 4 presents the estimated avoided greenhouse gas (GHG) emissions of the proposed code change for the first year the standards are in effect. Assumptions used in developing the GHG savings are provided in Section 4.8.1 of this report.

The monetary value of avoided GHG emissions is included in TDV cost factors (TDV $) and is thus included in the Cost-effectiveness Analysis prepared for this report.

Table 4: Estimated Statewide Greenhouse Gas Emissions Impacts

	First Year Statewide	
	Avoided GHG Emissions ($MTCO_2e/yr$)	**Monetary Value of Avoided GHG Emissions (2016 $)**
Sales Canopies	438	TBD
Outdoor Sales Lots	134	TBD
TOTAL	572	TBD

Section 4.8.1 discusses the methodology and Section 5.3.1 shows the results of the greenhouse gas emission impacts analysis.

Water Use and Water Quality Impacts

The proposed measure is not expected to have any impacts on water use or water quality, excluding impacts that occur at power plants.

Acceptance Testing

There are no new proposed acceptance testing requirements for the proposed measure.

1. INTRODUCTION

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (CEC) efforts to update California's Building Energy Efficiency Standards (Title 24) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison and Southern California Gas Company – and Los Angeles Department of Water and Power (LADWP) sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to energy efficiency in buildings. This report and the code change proposal presented herein is a part of the effort to develop technical and cost-effectiveness information for proposed regulations on building energy efficient design practices and technologies.

The overall goal of this CASE Report is to propose a code change proposal that would impact the lighting controls requirements for Outdoor Sales Canopies and Outdoor Sales Lots. The report contains pertinent information that justifies the code change.

Section 2 of this CASE Report provides a description of the measure, how the measure came about, and how the measure helps achieve the state's zero net energy (ZNE) goals. This section presents how the Statewide CASE Team envisions the proposed code change would be enforced and the expected compliance rates. This section also summarizes key issues that the Statewide CASE Team addressed during the CASE development process, including issues discussed during a public stakeholder meeting that the Statewide CASE Team hosted in May 2014.

Section 3 presents the market analysis, including a review of the current market structure, a discussion of product availability, and the useful life and persistence of the proposed measure. This section offers an overview of how the proposed standard will impact various stakeholders including builders, building designers, building occupants, equipment retailers (including manufacturers and distributors), energy consultants, and building inspectors. Finally, this section presents estimates of how the proposed change will impact statewide employment.

Section 4 describes the methodology and approach the Statewide CASE Team used to estimate energy, demand, costs, and environmental impacts. Key assumptions used in the analyses can be also found in Section 4.

Results from the energy, demand, costs, and environmental impacts analysis are presented in Section 5. The Statewide CASE Team calculated energy, demand, and environmental impacts using two metrics: (1) per unit, and (2) statewide impacts during the first year buildings complying with the 2016 Title 24 Standards are in operation. Time Dependent Valuation (TDV) energy impacts, which accounts for the higher value of peak savings, are presented for the first year both per unit and statewide. The incremental costs, relative to existing conditions are presented as are present value of year TDV energy cost savings and the overall cost impacts over the year period of analysis.

The report concludes with specific recommendations for language for the Standards, Appendices, Alternate Calculation Manual (ACM) Reference Manual and Compliance Forms.

This is a draft version of the CASE Report. The 2016 TDV values were not yet available when this draft report was being developed. The TDV energy and cost savings presented in this draft report were developed using 2013 TDV values. The TDV energy and cost savings presented in this draft report were developed using 2013 TDV values and TDV cost saving are in 2011 dollars. The Statewide CASE Team will be submitting a revised version of this report in fall 2014, which will include the final recommended code change proposal and a updated TDV energy and cost savings results that use the 2016 TDV values.

2. MEASURE DESCRIPTION

2.1 Measure Overview

2.1.1 Existing Standards

Section 130.2(c) of Title 24 contains controls requirements for outdoor lighting systems. The requirements apply to most outdoor lighting systems, including parking and other common outdoor hardscape areas. The standards require several different layers of controls, designed to accomplish different types of savings, including:

1. ensure that lights are turned off during daylight hours (photocontrol or astronomical time switch) (130.2(c)1)
2. ensure that outdoor luminaires can be controlled independently and be scheduled to be turned off during certain hours of the night (automatic scheduling control) (130.2(c) 2.)
3. ensure luminaires mounted under 24’ automatically reduce power between 40 – 80%, in response to vacancy of the space (occupancy-based multi-level lighting control) (130.2(c)3)

This last item, a requirement for motion-based bi-level or dimming systems, includes several exceptions. Among those are exceptions for Outdoor Sales Canopies and Outdoor Sales Lots. These space types are instead required to meet the control requirements in a subsequent section (130.2(c)4). This section requires luminaires in these space types to be equipped with *either* a motion-controlled, bi-level/dimming system OR a “Part-night Outdoor Lighting Control.”

A “Part-Night Outdoor Lighting Control,” is defined in Section 100.1 is a “time or occupancy-based lighting control device or system that is programmed to reduce or turn off the lighting power to an outdoor luminaire for a portion of the night.”

In other words, Outdoor Sales Frontage and Outdoor Sales Canopies can comply with code by installing occupancy-based dimming controls or by installing a time-based control instead. However, the time-based control requirement may be duplicative with the automatic scheduling control, which is also able to turn off power to outdoor luminaires for part of the night. Section 2.1.3 below provides more detail about the differences between these two control options and the benefits of an occupancy-based, dimming control.

2.1.2 Measure History

Outdoor lighting controls requirements were introduced in the 2008 Title 24 code update (effective 1/1/2010) and expanded in the 2013 code (effective 7/1/2014). The 2008 code required outdoor lighting to have either a photocontrol system or an automatic scheduling control system; the 2013 code required both, and also added the motion control requirement. The proposal to add the motion-based control requirements in the 2013 code were being developed in 2010-2011, and at that time exceptions were included for the bi-level motion-based control requirements in certain space types. The exceptions may have been inserted into the code because these types of motion-based, multi-level lighting controls installations were not being installed in sales lots and sales canopies, but in recent years they have started to occur more often.

The part-night control may have been envisioned as a stronger requirement than that automatic scheduling control because the part-night controls were intended to be mounted on the luminaires themselves, and therefore harder to manually override. However, this was not clearly defined and in the time since the code was adopted, many of these controls may now be controlled wirelessly, making them quite easy to override.

2.1.3 Measure Description

This measure would broaden the existing mandatory controls requirements by removing the exceptions from the occupancy-based bi-level/dimming controls requirements for Outdoor Sales Lots and Sales Canopies. These requirements, which are in Section 130.2(c), require control capability to dim the system to between 40% and 80% of full output wattage in response to vacancy, and to provide auto-on functionality in response to occupancy. The measure also considers increasing the maximum allowable dimmed range beyond 80%. The Statewide CASE Team is currently seeking input from stakeholders on this issue but has tentatively proposed increasing to 90%. Other existing exemptions would remain unchanged, including those based on luminaire height and luminaire wattage.

Luminaires in Outdoor Sales Lots and Outdoor Sales Canopies are allowed to utilize a “Part-Night Outdoor Lighting Control,” which, as defined in Section 100.1 is a “time or occupancy-based lighting control device or system that is programmed to reduce or turn off the lighting power to an outdoor luminaire for a portion of the night.” By not requiring the installation of occupancy-based multi-level control systems a significant savings opportunity may be lost. Some, but not all, of the potential reasons for lost savings are provided here:

- The part-night control requirement does not specify how much power must be reduced, nor for what portion of the night, so even in facilities that are closed for much of the night, these controls could be programmed to provide very minimal power reduction and still be code compliant.

- Many business owners may choose not to utilize (or to over-ride) part-night controls after business hours in order to ensure that lights are on at 100% in the event that anyone enters the property after hours.
- If a business changes hands, changes operating hours, or experiences other changes to normal operation, part-night controls may not be re-programmed to provide optimal savings (or they may be over-ridden if they're perceived to not fit the new operating practice).
- The part-night control is not likely to be utilized during business hours when lights are kept on for occupants, so they do not save energy in 24/7 facilities.

Occupancy-based multi-level controls ensure greater savings relative to these scenarios. They achieve savings regardless of whether a business is open or closed at night, so there is savings potential both in 24/7 facilities, facilities that operate for significant periods of time during the night, and in facilities that are closed for much or all of the night but which often leave lighting on. In a business that operates at night but with only intermittent occupancy (such as gas stations), bi-level motion controls will maintain lights at a low power state for much of the night, when no one is present, saving a considerable amount of energy. The controls will ramp up lighting to full power only when detecting motion, and then dim lights again in between customers. In facilities that are closed for most or all of the night, the measure will dim lights with the ability to ramp up should motion be detected, which can be a valuable safety feature for a facility like a sales lot, where increased light levels can draw attention to trespassers.

2.1.4 Alignment with Zero Net Energy Goals (ZNE)

The proposed code change will assist in California's nonresidential ZNE goals by reducing the electrical energy consumption of luminaires at the associated areas of non-residential buildings. Outdoor lighting represents a very significant amount of energy use in the state, consuming approximately 11,000-12,000GWh per year. This measure will assist with the State's goals established in Assembly Bill 1109, to reduce outdoor lighting energy consumption by 25%.

2.1.5 Relationship to Other Title 24 Measures

The proposed code change is related to the lighting power allowance (LPA) code change proposal being developed for nonresidential outdoor space types, including sales canopies and sales lots. The interaction of these two proposals has been considered through their development; this measure proposal, the energy impacts analysis, and the cost-effectiveness analysis presented in this report are based on the assumption that LPAs have been reduced to a primarily LED level.

2.2 Summary of Changes to Code Documents

The sections below provide a summary of how each Title 24 document will be modified by the proposed change. See Section 6 of this report for detailed proposed revisions to code language.

2.2.1 Catalogue of Proposed Changes

Scope

Table 5 identifies the scope of the code change proposal. This measure will impact the following areas (marked by a "Yes").

Table 5: Scope of Code Change Proposal

Mandatory	Prescriptive	Performance	Compliance Option	Trade-Off	Modeling Algorithms	Forms
Yes						TBD

Standards

The proposed code change will modify the sections of the California Building Energy Efficiency Standards (Title 24, Part 6) identified in Table 6.

Table 6: Sections of Standards Impacted by Proposed Code Change

Title 24, Part 6 Section Number	Section Title	Mandatory (M) Prescriptive (Ps) Performance (Pm)	Modify Existing (E) New Section (N)
130.2(c)	Outdoor Lighting Controls and Equipment	M	E

Appendices

The proposed code change will not modify any sections in the appendices.

Residential/Nonresidential Alternative Calculation Method (ACM) Reference Manual

The proposed code change will not modify the Residential or Nonresidential Alternative Calculation Method References.

Simulation Engine Adaptations

Because this is a mandatory measure, changes to the simulation engine are not necessary.

2.2.2 Standards Change Summary

This proposal would modify the following sections of the Building Energy Efficiency standards as shown below. See Section 6.1 of this report for the detailed proposed revisions to the standards language.

Changes in Mandatory Requirements

The proposed code change will remove the exceptions to the controls requirements for Outdoor Sales Lots and Outdoor Sales Canopies that currently exist in Section 130.2(c) of the current code. In response to stakeholder input, the proposal also considers changing the upper limit currently placed on the allowed wattage reduction (80%).

SECTION 130.2- OUTDOOR LIGHTING CONTROLS AND EQUIPMENT

(c) Controls for Outdoor Lighting

EXCEPTION 1 to Subsection 130.2(c): The proposed code change will remove "Outdoor Sales Lots" and "Outdoor Sales Canopies" from this exception.

2.2.3 Standards Reference Appendices Change Summary

This proposal will not modify any sections of the Standards Appendices.

2.2.4 Nonresidential Alternative Calculation Method (ACM) Reference Manual Change Summary

This proposal would not modify the Alternative Calculation Method (ACM) Reference Manuals.

2.2.5 Compliance Forms Change Summary

The proposed code change will utilize the following compliance forms listed below. The proposed code change may require minor changes to the following Compliance Form:

- **NA7.8** – Outdoor Lighting Controls Installed to Comply with Section 130.2(c)

2.2.6 Simulation Engine Adaptations

Because this is a mandatory outdoor lighting measure, it does not need to be modeled by the building simulation engine.

2.2.7 Other Areas Affected

No other areas will be affected.

2.3 Code Implementation

2.3.1 Verifying Code Compliance

The proposed code change will utilize the same verification techniques defined in Nonresidential Appendix NA7.8 for Outdoor Lighting Controls Installed to Comply with Section 130.2(c).

2.3.2 Code Implementation

The proposed code change is a streamlining of the current code and it applies the current requirements to more space types. It represents a design strategy already very common in other space types, and code requirements that will be enforced in other space types effective 7/1/2014. It will not be any more difficult for building inspectors to verify compliance than the current 2013 code compliance verification process for other outdoor space types. Further, the industry will gain significant experience implementing these control strategies as a result of the 2013 code. However, the majority of new sales lots and sales canopy facilities do not currently employ this strategy (and are not required to do so under the 2013 code) so it will represent a change from the status quo in these space types. The measure also represents an added first cost, though not a significant expense relative to the overall project costs for new sales lots or gas stations.

2.3.3 Acceptance Testing

The measure will need to utilize the existing Acceptance Testing located in Nonresidential Appendix NA7.8.1.2.

2.4 Issues Addressed During CASE Development Process

The Statewide CASE Team solicited feedback from a variety of stakeholders when developing the code change proposal presented in this report. In addition to personal outreach to key stakeholders, the Statewide CASE Team conducted a public stakeholder meeting to discuss the proposals. The issues that were addressed during development of the code change proposal are summarized below.

- Design strategies: The Statewide CASE Team held discussions with manufacturers about the various design strategies that could be employed to comply with the motion control requirements, and the potential wiring set-up.
- Compliance costs: The Statewide CASE Team held discussions with manufacturers of products that would comply with standards and obtained estimates of incremental cost.
- Existing installations: The Statewide CASE Team held discussions with utility program managers around the country with experience running bi-level controls projects in car dealerships. The Statewide CASE Team has also communicated directly with facility managers who have implemented bi-level motion controlled lighting installations and obtained user feedback.
- Safety implications of reduced light levels: The Statewide CASE Team has communicated with multiple parties involved with completed bi-level controls projects at gas stations and car lots (including manufacturers, facility managers, and utility program managers) and all have provided positive reviews of the projects and did not express concerns about safety associated with dimmed light levels. Rather, these individuals all indicated they expect to see these types of controls installed at more facilities.
- The Statewide CASE Team is also aware of the potential implications of reduced light levels on facility marketing efforts. While this concern has not been raised directly by stakeholders in the development of this code proposal, it has been considered to be a possible point of concern in the past. The Statewide CASE Team believes these impacts to be minimal because in this proposal lights are not required to be turned off, but rather to be dimmed to at least 40% below full output (i.e. to 60%). Further, it is well understood in lighting design that as light levels are reduced, the relationship between perceived light levels and measured light levels is not linear. As the formula in the Illuminating Engineering Society 10th Edition Handbook explains, a light level reduction of 40% is only perceived as a 22.5% reduction in light. In other words, facility owners that wish to maintain illumination on the facility for marketing purposes will still be allowed to do so. The formula explaining the relation between measured light and

perceived light is provide here (IESNA Lighting Handbook, 9th Edition, (New York; IESNA, 2000), 27-4):

$$\text{Formula: Perceived Light (\%)} = 100 \times \sqrt{\frac{\text{Measured Light (\%)}}{100}}$$

- Appropriateness of existing limits on dimmed levels: In the current code, automatic lighting controls are not allowed to reduce power by more than 80% of full power. The Statewide CASE Team discussed with stakeholders the appropriateness of this current maximum allowable dimmed level in the code, and explored rationale and options for updating that value to a higher number.

3. MARKET ANALYSIS

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. The Statewide CASE Team considered how the proposed standard may impact the market in general and individual market players. The Statewide CASE Team gathered information about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with key stakeholders including utility program staff, CEC, and a wide range of industry players who were invited to participate in a public stakeholder meeting that the Statewide CASE Team hosted in May 2014.

3.1 Market Structure

This measure proposes to require occupancy-based bi-level or continuous dimming lighting systems in gas station canopy fixtures and auto sales lots. These types of systems are made up of two components: dimmable luminaires and occupancy control systems. Dimmable canopy luminaires and dimmable area (pole-mounted, wall-mounted etc.) fixtures are available from a wide array of lighting manufacturers, including Cree, General Electric, Lithonia, Acuity, Philips, Leotek, MaxLite and many others. On the occupancy controls side, there are two typical controls configurations, circuit-controlled and fixture-integrated controls. Circuit-controlled outdoor occupancy control systems are commonly available from a variety of manufacturers, including Cooper, Hubbell, Wattstopper, Steinel, and Lumewave. Several of the aforementioned manufacturers now market fixture-integrated control systems as well, some of which offer wireless communication to optimize performance.

3.2 Market Availability and Current Practices

Though high intensity discharge (HID) fixtures have shown improvement in their dimming capabilities over the years, and occupancy control systems currently exist for a variety of outdoor lighting technologies including HID fixtures (primarily metal halide), this report assumes new fixtures will be LEDs. LEDs are much more easily and commonly dimmable than most lighting technologies – they are generally dimmable down to 10% of full light output, or lower. Outdoor fixture trends are moving to LED quickly as LED prices come down, and because LEDs offer much more customization for controls, deeper dimmability, quicker response, and linear power versus light characteristics (with neither efficacy nor light quality materially affected during dimming). The Outdoor Lighting LPA CASE Report is also proposing new lighting power requirements that will most likely be met by LED sources.

Occupancy-based control systems are frequently used in parking lots and other outdoor lighting systems and will be even more common after the 2013 standards become effective. Of the typical controls configurations, circuit controlled and fixture-integrated controls, both are commonly installed in many outdoor lighting new construction applications today. Expanding the existing Title 24 requirements to apply to gas stations and car dealerships will slightly increase demand for these technologies, but it is not expected to create any supply issues, as this will be a relatively small incremental growth for this control strategy, and the Standards do not take effect until approximately two years after they are adopted.

Relevant product offerings with integrated-sensors include:

- Lumewave TOP900 Series Pole Fixtures with Wattstopper sensors mounted to each fixture
- Cree CPY Series Canopy and Soffit Luminaire
- Cree 304 Series Canopy

In conjunction with other controls requirements already in place (e.g. photocells, time clocks) controls strategies can be designed to optimize outdoor lighting efficiency. For example, controls can bring lights on to 70% shortly after sunset, then gradually to 100% as the night darkens, and then provide high/low operation of 100% to 50% based on the presence of people. After a certain hour, systems can be programmed to dim further when people are not present, for example dropping high/low operation to 100% and 30%. Another option is to design , install, tune, and commission fully autonomous motion sensor-coupled dimmable LED systems that solve safety issues assuring full light is there if activity is there. Longer range microwave sensors (Lumewave for example) are greatly expanding coverage eliminating chronic overlap problems associated with PIR tech.

Most sensors are offered with a range of programmable response times (the length of vacancy before lights return to their dimmed state). Most sensors offer a 1 minute or 30 second minimum response time, though some offer even shorter responses (e.g. 15 seconds). On the other end of the range, many sensors offer a 30 minute maximum response time.

3.3 Useful Life, Persistence, and Maintenance

This measure is expected to have very high persistence of savings because it is occupancy based and does not depend on ongoing commissioning, for example if businesses change hands or change operating hours. Because systems will provide light whenever occupants are present, they are less likely to be over-ridden by building managers. Product lifetimes are assumed to be longer than the period of analysis (15 years), so replacements will not be required within the period of analysis. There are also no assumed incremental maintenance costs for this measure.

The Statewide CASE Team is continuing to investigate sensor lifetime in accordance with stakeholder feedback. In the case that sensor lifetimes are determined to be less than the period of analysis, the Statewide CASE Team will incorporate the cost of sensor replacement into the final report.

3.4 Market Impacts and Economic Assessments

3.4.1 Impact on Builders

The proposed code change is not expected to have an impact on builders. Controls systems commonly installed in other outdoor lighting projects will now also be required for additional area types.

3.4.2 Impact on Building Designers

Building designers will need to incorporate control design into the construction of sales canopies and sales lots. However, this is not expected to be overly cumbersome from a design standpoint – particularly the integrated-fixture approach, which will require very little additional expertise for building designers.

3.4.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Department of Occupational Safety and Health (Cal/OSHA). All existing health and safety rules will remain in place. Complying with the proposed code change is not anticipated to have any negative impact on the safety or health occupants or those involved with the construction, commissioning, and ongoing maintenance of the building. There has been some discussion with stakeholders about the potential implications for safety at the sites covered by this proposal. It has been suggested because light levels will instantly increase whenever motion is detected on the premises, the measure may increase safety and awareness of occupants and workers in these facilities.

3.4.4 Impact on Building Owners and Occupants

Since this measure is cost effective, the building owners are reducing their energy costs more than their mortgage costs are increased as a result of this measure (i.e. they experience net cost savings). For building occupants that are paying for their energy bills, since the measure saves more energy cost on a monthly basis than the measure costs on the mortgage as experienced by the building owner, the pass-through of added mortgage costs into rents is less than the energy cost savings experienced by occupants.

3.4.5 Impact on Retailers (including manufacturers and distributors)

Equipment retailers will need to consider the increased demand for control systems due to this measure.

3.4.6 Impact on Energy Consultants

Energy consultants will need to consider the new code baseline of lighting equipment in sales lots and sales canopies.

3.4.7 Impact on Building Inspectors

As compared to the overall code enforcement effort, this measure has negligible impact on the effort required to enforce the building codes.

3.4.8 Impact on Statewide Employment

The proposed code change is not expected to have an impact on Statewide employment.

3.5 Economic Impacts

The proposed Title 24 code changes, including this measure, are expected to increase job creation, income, and investment in California. As a result of the proposed code changes, it is anticipated that less money will be sent out of state to fund energy imports, and local spending is expected to increase due to higher disposable incomes due to reduced energy costs.[2] In addition, more dollars will be spent in state on improving the energy efficient of new buildings.

These economic impacts of energy efficiency are documented in several resources including the California Air Resources Board's (CARB) Updated Economic Analysis of California's Climate Change Scoping Plan, which compares the economic impacts of several scenario cases (CARB, 2010b). CARB include one case (Case 1) with a 33% renewable portfolio standard (RPS) and higher levels of energy efficiency compared to an alternative case (Case 4) with a 20% RPS and lower levels of energy efficiency. Gross state production (GSP)[3], personal income, and labor demand were between 0.6% and 1.1% higher in the case with the higher RPS and more energy efficiency (CARB 2010b, Table 26). While CARB's analysis does not report the benefits of energy efficiency and the RPS separately, we expect that the benefits of the package of measures are primarily due to energy efficiency. Energy efficiency measures are expected to reduce costs by $2,133 million annually (CARB 2008, pC-117) whereas the RPS implementation is expected to cost $1,782 million annually, not including the benefits of GHG and air pollution reduction (CARB 2008, pC-130).

Macro-economic analysis of past energy efficiency programs and forward-looking analysis of energy efficiency policies and investments similarly show the benefits to California's economy of investments in energy efficiency (Roland-Holst 2008; UC Berkeley 2011).

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[2] Energy efficiency measures may result in reduced power plant construction, both in-state and out-of-state. These plants tend to be highly capital-intensive and often rely on equipment produced out of state, thus we expect that displaced power plant spending will be more than off-set from job growth in other sectors in California.

[3] GSP is the sum of all value added by industries within the state plus taxes on production and imports.

3.5.1 Creation or Elimination of Jobs

CARB's economic analysis of higher levels of energy efficiency and 33% RPS implementation estimates that this scenario would result in a 1.1% increase in statewide labor demand in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b, Tables 26 and 27). CARB's economic analysis also estimates a 1.3% increase in small business employment levels in 2020 (CARB 2010b, Table 32).

3.5.2 Creation or Elimination of Businesses within California

CARB's economic analysis of higher levels of energy efficiency and 33% RPS implementation (as described above) estimates that this scenario would result in 0.6% additional GSP in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b, Table ES-2). We expect that higher GSP will drive additional business creation in California. In particular, local small businesses that spend a much larger proportion of revenue on energy than other businesses (CARB 2010b, Figures 13 and 14) should disproportionately benefit from lower energy costs due to energy efficiency standards. Increased labor demand, as noted earlier, is another indication of business creation.

Table 7 below shows California industries that are expected to receive the economic benefit of the proposed Title 24 code changes. It is anticipated that these industries will expand due to an increase in funding as a result of energy efficiency improvements. The list of industries is based on the industries that the University of California, Berkeley identified as being impacted by energy efficiency programs (UC Berkeley 2011 Table 3.8).[4] This list provided below is not specific to one individual code change proposal, rather it is an approximation of the industries that may receive benefit from the 2016 Title 24 code changes. A table listing total expected job creation by industry that is expected in 2015 and 2020 from all investments in California energy efficiency and renewable energy is presented in the

[4] Table 3.8 of the UC Berkeley report includes industries that will receive benefits of a wide variety of efficiency interventions, including Title 24 standards and efficiency programs. The authors of the UC Berkeley report did not know in 2011 which Title 24 measures would be considered for the 2016 adoption cycle, so the UC Berkeley report was likely conservative in their approximations of industries impacted by Title 24. Statewide CASE Team believes that industries impacted by utilities efficiency programs is a more realistic and reasonable proxy for industries potentially affected by upcoming Title 24 standards. Therefore, the table provided in this CASE Report includes the industries that are listed as benefiting from Title 24 and utility energy efficiency programs.

Appendix B: Job Creation by Industry of this CASE Report.

Table 7: Industries Receiving Energy Efficiency Related Investment, by North American Industry Classification System (NAICS) Code

Industry	NAICS Code
Residential Building Construction	2361
Nonresidential Building Construction	2362
Roofing Contractors	238160
Electrical Contractors	23821
Plumbing, Heating, and Air-Conditioning Contractors	23822
Boiler and Pipe Insulation Installation	23829
Insulation Contractors	23831
Window and Door Installation	23835
Asphalt Paving, Roofing, and Saturated Materials	32412
Manufacturing	32412
Other Nonmetallic Mineral Product Manufacturing	3279
Industrial Machinery Manufacturing	3332
Ventilation, Heating, Air-Conditioning, & Commercial Refrigeration Equip. Manf.	3334
Computer and Peripheral Equipment Manufacturing	3341
Communications Equipment Manufacturing	3342
Electric Lighting Equipment Manufacturing	3351
Household Appliance Manufacturing	3352
Other Major Household Appliance Manufacturing	335228
Used Household and Office Goods Moving	484210
Engineering Services	541330
Building Inspection Services	541350
Environmental Consulting Services	541620
Other Scientific and Technical Consulting Services	541690
Advertising and Related Services	5418
Corporate, Subsidiary, and Regional Managing Offices	551114
Office Administrative Services	5611
Commercial & Industrial Machinery & Equip. (exc. Auto. & Electronic) Repair & Maint.	811310

3.5.3 Competitive Advantages or Disadvantages for Businesses within California

California businesses would benefit from an overall reduction in energy costs. This could help California businesses gain competitive advantage over businesses operating in other states or countries and an increase in investment in California, as noted below.

3.5.4 Increase or Decrease of Investments in the State of California

CARB's economic analysis indicate that higher levels of energy efficiency and 33% RPS will increase investment in California by about 3% in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b Figures 7a and 10a).

3.5.5 Incentives for Innovation in Products, Materials, or Processes

Updating Title 24 standards will encourage innovation through the adoption of new technologies to better manage energy usage and achieve energy savings. This particular proposal supports the adoption of innovative occupancy based multi-level lighting controls.

3.5.6 Effects on the State General Fund, State Special Funds and Local Governments

The Statewide CASE Team expects positive overall impacts on state and local government revenues due to higher GSP and commercial enterprise profit margins resulting in higher tax revenues, as noted earlier. Higher property valuations due to energy efficiency enhancements may also result in positive local property tax revenues. The Statewide CASE Team has not obtained specific data to quantify potential revenue benefits for this measure.

3.5.6.1 Cost of Enforcement

Cost to the State

State government already has budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24 standards, including updating education and compliance materials and responding to questions about the revised standards, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall costs savings and policy benefits associated with the code change proposals.

Cost to Local Governments

All revisions to Title 24 will result in changes to Title 24 compliance determinations. Local governments will need to train permitting staff on the revised Title 24 standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2016 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining. For example, utilities offer compliance training such as "Decoding" talks to provide training and materials to local permitting departments. As noted earlier, although retraining is a cost of the revised standards, Title 24 energy efficiency standards are expected to increase economic growth and income with positive impacts on local revenue.

This standard would revise an existing measure without significantly affecting the complexity of this measure. Therefore, on-going costs are not expected to change significantly.

3.5.6.2 Impacts on Specific Persons

The proposed changes to Title 24 are not expected to have a differential impact on any of the following groups relative to the state population as a whole:

- Migrant Workers
- Persons by age
- Persons by race
- Persons by religion
- Commuters

4. METHODOLOGY

This section describes the methodology and approach the Statewide CASE Team used to estimate energy, demand, costs, and environmental impacts. The Statewide CASE Team calculated the impacts of the proposed code change by comparing existing conditions to the conditions if the proposed code change is adopted. This section of the CASE Report goes into more detail on the assumptions about the existing and proposed conditions, prototype buildings, and the methodology used to estimate energy, demand, cost, and environmental impacts.

4.1 Existing Conditions

To assess the energy, demand, costs, and environmental impacts, the Statewide CASE Team compared current design practices to design practices that would comply with the proposed requirements. There is an existing Title 24 standard that covers the building system in question (a requirement for part-night controls), however because the code does not require any specific operation of the part-night control, the energy use of such systems is unclear. The current proposed standard replaces the part-night control requirement with an occupancy-based dimming control requirement. For the purposes of the cost-effectiveness analysis, the existing condition is assumed to be a facility not utilizing or optimizing the part-night controls or the automatic scheduling controls, so lights are presumed to be on at night in the baseline facility. The baseline facility does have the other required time clock / photocell controls, so lights are therefore assumed to be turned off during all daylight hours.

The Statewide CASE Team conducted an analysis of different facility types, with different operating hours. Research conducted by the Statewide CASE Team found that 65% of gas stations in California are open 24 hours a day, while the remaining 35% are open an average of 15 hours per day (~7:00 AM to ~10:00 PM). These values were derived based on a mix of rural, suburban, and urban stations, in both Northern California and Southern California, and including both big name chains and smaller independent operations. A similar survey of auto-dealerships found that almost all auto-dealerships are open for most of the day and closed at night. Typical operating hours for auto sales lots are 8:00 AM to 8:00 PM. This report therefore assumes the most common affected facility types are 24-hour gas stations, 15-hour gas stations (7:00 AM -10:00 PM), and 12-hour auto sales lots.

4.2 Proposed Conditions

The proposed conditions are defined as the design conditions that will comply with the proposed code change. Specifically, for this analysis, the proposed condition assumes that fixture-integrated occupancy-based control systems are installed in the covered area types. The proposed conditions assume that the controls ramp up lights to full power when occupants are present and then ramp down fixture power after vacancy is detected. Separate analyses were performed assuming different levels of power reduction during un-occupied time, different amounts of un-occupied time, and different sensor response settings, to represent a range of savings potential. Detailed description of all assumptions and calculation methodology is available below in Section 4.6 of this report.

4.3 Prototype Buildings

CEC does not provide guidance on prototype building design for the outdoor lighting area types affected by this code proposal. The Statewide CASE Team has used the same prototype area types used in development of the 2013 Outdoor Lighting Standards, including a Large Outdoor Sales Canopy (8,682 square feet), a small Outdoor Sales Canopy (3,006 square feet), and a small corner Outdoor Sales Lot (13,156 square feet).

A stakeholder has provided feedback that there are a non-trivial number of sites that are 5 to10 times larger than our largest prototype site. The Statewide CASE Team is investigating this issue, and we may update our methodology to incorporate the impact of these larger sites in the analyses that are presented in the final report. By excluding these larger sites, the energy savings estimates presented in this version of the are more conservative than what might be realized if the code change proposal is adopted.

Table 8 presents the details of the prototype area types used in the analysis.

Table 8: Prototype Space Types used for Energy, Demand, Cost, and Environmental Impacts Analysis

	Occupancy Type	Area (square feet)	Number of Fixtures	Operating Hours
Prototype 1	Large Sales Canopy	8,682	36	24 hours
Prototype 2	Large Sales Canopy	8,682	36	7:00 AM – 10:00PM
Prototype 3	Small Sales Canopy	3,006	16	24 hours
Prototype 4	Small Sales Canopy	3,006	16	7:00 AM – 10:00 PM
Prototype 5	Corner Outdoor Sales Lot	13,156	10[1]	8:00 AM – 8:00 PM

1. Does not include sales frontage fixtures

4.4 Climate Dependent

Since this measure is not climate sensitive, it is not necessary to model savings in every climate zone and statewide average TDV factors were used in the energy and cost analysis.

4.5 Time Dependent Valuation

The Time Dependent Valuation (TDV) of savings is a normalized format for comparing electricity and natural gas savings that takes into account the cost of electricity and natural gas consumed during different times of the day and year. The TDV values are based on long term discounted costs (30 years for all residential measures and nonresidential envelope measures and 15 years for all other nonresidential measures). In this case, the period of analysis used is 15 years. The TDV cost impacts are presented in 2016 present value dollars. The TDV energy estimates are based on present-valued cost savings but are normalized in terms of "TDV kBTUs" so that the savings are evaluated in terms of energy units and measures with different periods of analysis can be combined into a single value.

This is a draft version of the CASE Report. The 2016 TDV values were not yet available when this draft report was being developed. The TDV energy and cost savings presented in this draft report were developed using 2013 TDV values. Despite what the table headings indicate, the TDV energy and cost savings presented in this draft report were developed using 2013 TDV values and TDV cost saving are in 2011 dollars. The Statewide CASE Team will be submitting a revised version of this report in fall 2014, which will include the final recommended code change proposal and a updated TDV energy and cost savings results that use the 2016 TDV values.

CEC derived the 2016 TDV values that were used in the analyses for this report (CEC 2014a). The TDV energy impacts are presented in Section 5.1 of this report, and the statewide TDV cost impacts are presented in Section 5.2 of this report.

4.6 Energy Impacts Methodology

The Statewide CASE Team calculated per unit impacts and statewide impacts associated with all new construction, alterations, and additions during the first year buildings complying with the 2016 Title 24 Standards are in operation. To calculate the measure impacts, the Statewide CASE Team has conducted preliminary research into these markets in order to develop an hourly savings model based on typical occupancy patterns and typical system design strategies. The following sections provide an explanation of the model used and the key assumptions used in the model.

4.6.1 Per Unit Energy Impacts Methodology

The Statewide CASE Team estimated the electricity savings associated with the proposed code change. The energy savings were calculated both on a per fixture and per site basis.

Analysis Tools

The Statewide CASE Team utilized spreadsheet analysis to model the energy savings throughout each night of the year, in each prototype facility, under each facility's assumed operating hours.

Key Assumptions

The energy savings potential from an occupancy-based control measure is heavily dependent on the occupancy patterns of the space types in question, in terms of frequency and duration of occupancy, sensor response times, assumed fixture wattages, and assumed power levels when dimmed. The Statewide CASE Team conducted observations at both gas stations and auto sales lot properties and is arranging for additional site monitoring efforts with occupancy sensor data loggers to verify all assumptions used in the model. In the interim, the Statewide CASE Team has populated a model with a range of conservative assumptions and early observations for each prototype space type, to bind the savings potential and determines cost-effectiveness thresholds. The key assumptions used in the per unit energy impacts analysis that are not already included in the assumptions provided in the LCC Methodology are described below and then presented in Table 9.

Dimmed Levels

The current requirements for motion control outdoor lighting fixtures are that systems be able dim to between 40% and 80% of full output wattage in response to detection of occupancy. The Statewide CASE Team has run simulations assuming a dimmed level in the middle of that range, or systems that are dimmed 60% below full power.

Fixture Wattages

The Statewide CASE Team modeled gas station canopies using both 122 watts (W) and 82W LED fixtures, both typical values for canopy fixtures. For auto sales lot, the Statewide CASE Team modeled area fixtures at 202W and 126W, common wattages among area LED fixtures. The Statewide CASE Team has received stakeholder feedback that higher LED wattages are commonly used for area lighting. The magnitude of the savings achieved through dimming is proportional to the fixture wattage; dimming higher wattage fixtures will result in higher savings than dimming lower wattage fixtures. Since higher wattage LED fixtures are sometimes used in auto sales lots, the statewide savings estimates presented in this report, which assumes 126W and 202W fixtures for auto sales lots, may be conservative. In the final report, we may incorporate this feedback and re-evaluate the wattages used in our auto sales lot calculations.

Sensor Activation and Response Times

Outdoor sensors can generally be programmed to decrease power after 30 seconds to 30 minutes of vacancy, and common installations range from 2 minutes or less, up to 15 minutes. Historically, sensors installed with T8 or other fluorescent systems had longer response times to minimize rapid cycling of lamps and to avoid negative effects on lamp life. LED fixtures do not have such limitations and thus shorter response times are practical. This savings analysis has assumed a range in sensor response time between 4 and 6 minutes, which is equivalent to the amount of time spent in gas stations by occupants at night.

The Statewide CASE Team has also made an extremely conservative assumption about sensor activation, in that any time an occupant arrives in a facility, all sensors are assumed to be triggered and all fixture powers are increased to full brightness. In reality, many night time occupancy events in outdoor sales lots and sales canopies will trigger some of the sensors but not others. Facility engineers may decide to program all of the fixtures at a site to dim and brighten together for aesthetic reasons; however, the Statewide CASE Team recognizes that for those facilities that allow the controls to operate independently our current calculation methodology significantly underestimates the measure savings. As such, we will consider updating our calculations account for independent dimming.

Gas Station Occupancy Patterns for 24 Hour Facilities

For gas stations and auto-dealerships that close for the majority of the night, the Statewide CASE Team assumed very little occupancy would happen in the middle of the night and sensors would not be triggered frequently (one to two occupant events per hour, conservatively). However, in the case of the 24-hour gas stations, the Statewide CASE Team has conducted research to inform assumptions about length of time spent in gas stations by customers at night and rates of customer visits at different hours of the night. Several sources were used to assess length of time spent in gas stations.

- A study by All Over Media found gas station visit times ranged from 3 to 5 minutes.[5]

[5] http://www.allovermedia.com/our-solutions/gas-pump/

- A study on urban refueling behavior (with a focus on common long lines at gas stations in Beijing) found a range of time spent at gas stations from 6 to 14 minutes, with the 6 minute trips occurring at night.[6]
- Statewide CASE Team's own monitoring of California gas station duration times at night found an average of 3.8 minutes.
- Available data points were averaged for this study, resulting in an assumed length of night time gas station occupancy of 4.5 minutes per visit/fueling event.
- A stakeholder has provided input to the Statewide CASE Team that the time per fueling event may be significantly longer than 4.5 minutes at truck service stations. The Statewide CASE Team recognizes that truck fueling stations have different occupancy patterns than car fueling stations, and we are exploring options to address this issue. The final version of this CASE Report, which will be submitted in fall 2014, will provide our final recommendations for truck fueling stations.

In terms of occupancy rates, various studies are available suggesting that the vast majority of consumers visit gas stations during the day. In one recent survey with 20,000 respondents, fewer than 4% of respondents reported they regularly fill up their gas tanks between 10 PM and 5:00 AM.[7] The aforementioned study from Zhang et. al. found that about 16% of fuel station visits occurred between 10:00 PM and 5:00 AM and that the vast majority of gas station fill-ups occurred between 9:00 AM – 12:00 PM and between 2:00 PM – 6:00 PM. The hours between 7:00 AM – 9:00 AM and between 6:00 – 8:00 PM represented a middle tier of occupancy, with significantly fewer gas station visits than during the peak hours, but significantly more visits than during the late night hours. Because this study only addresses night time hours, the Statewide CASE Team utilized these findings to define two distinct periods of night occupancy patterns:

- Higher occupancy night hours
  - From 7:00 AM to sunrise (only relevant in parts of the year when sunrise occurs after 7:00 AM)
  - From sunset to 8:00 PM (only relevant in parts of the year when sunset occurs before 8:00 PM)
- Lower occupancy night time hours
  - From 8:00 PM until 7:00 AM

As more precise occupancy patterns become available they can be plugged into the savings model, but for now, based on preliminary observations, the model has been developed to assume gas stations that are open at night receive 15 customers per hour during the higher occupancy hours, and 6 customers per hour during the low occupancy hours. These are

[6] Fuzheng Zhang, David Wilkie, Yu Zheng, and Xing Xie; http://research.microsoft.com/apps/pubs/?id=196236
[7] http://www.gasbuddy.com/GB_Past_Polls.aspx?poll_id=195

conservative values based on monitoring data that included some night time station occupancy patterns at a rate of only 1 to 2 customers per hour, and a maximum observed occupancy rate of 15 customers per hour.

Exponential Distribution of Night Occupancy Events

Given these parameters and an assumed average rate of occupants per hour, the Statewide CASE Team completed a statistical analysis to determine the average amount of time lighting systems would actually be dimmed. Assuming an average rate of occupants per hour (λ), an exponential distribution was calculated to better reflect likely occupancy patterns. This is a widely used statistical tool to model waiting times or other similar events.[8]

Roughly speaking, the time X before an event occurs has an exponential distribution if the probability that the event occurs during a certain time interval is proportional to the length of that time interval. This is true when the event is equally likely to happen at any given moment within the time period and if events occur independently of one another. We have assumed that the next occupant in a space is equally likely to arrive at any given moment within a certain hour of the night (but allowed for the rate of occupants per hour to vary between hours of the night), which leads to an exponential distribution of expected times between occupants arriving.

In other words, if we assume an average of four occupants per hour ($\lambda = 4$), statistically speaking it is extremely improbable that those four occupants would arrive with a uniform distribution (i.e. exactly every fifteen minutes). It is also improbable that they would all arrive at the same time. Instead of assuming either of these extremes, the exponential distribution function allows us to assign a likelihood to different amounts of elapsed time between occupant arrivals. This function has been programmed into the savings model used by the Statewide CASE Team to estimate measure savings throughout every night time hour of the year.

8 http://www.statlect.com/ucdexp1.htm

Table 9: Key assumptions for per unit Energy Impacts Analysis

Parameter	Assumption Used in Savings Model	Source	Notes
Dimmed Levels	Fixtures dimmed 60% below full output power	Based on current standards	Derived as the midpoint between the dimming capability requirements (40% and 80%)
Fixture Wattage	122W and 82W for Canopies, 202W and 126W for Sales Lots	Spec sheets from major manufacturers, common wattage ranges, and consistent with Outdoor LPA CASE proposal which pushes market to LED	
Sensor Activation and Response Times	Response time: 4 minutes of continuous vacancy	Statewide CASE Team experience with similar project installations	Note that the current analysis assumes that all fixtures are activated (come to full brightness) any time anyone enters the space. In fact, in most cases, sensors may control sub-groups of luminaires (or individual luminaires) and only some of the sensors in a space may detect motion if an occupant passes through. Therefore not all fixtures will be brought to full power at each occupancy event.
Occupancy Patterns for 24 Hour Gas Stations	6 occupants per hour during deep night hours, 15 occupants per hour in the evening and early morning	Statewide CASE Team analysis and site observations	
Occupancy Patterns for non 24 hour facilities	1 occupant per hour after business hours, and 15 occupants per hour during business hours (night)	Statewide CASE Team analysis and site observations	

4.6.2 Statewide Energy Impacts Methodology

First Year Statewide Impacts

The Statewide CASE Team estimated statewide impacts for the first year buildings comply with the 2016 Title 24 Standards by multiplying per unit savings estimates by statewide construction forecasts.

For Outdoor Sales Lots, the Statewide CASE Team assumed the vast majority of savings will come from new and retrofitted car dealerships. There are 7,392 licensed auto sales dealers in

California.[9] The Statewide CASE Team estimates that approximately 70% of these (5,175) have outdoor sales lot spaces with pole or wall mounted luminaires below 24 feet high. Of these, the Statewide CASE Team estimates that 2% are new each year and 3% undergo major lighting retrofits, triggering code. The Statewide CASE Team therefore assumes that approximately 260 outdoor sales lots will be required to meet the proposed requirements each year. Of those, the Team has assumed half would utilize higher wattage luminaires (represented by 202W fixtures in this analysis), and half would utilize lower wattage area luminaires (126W fixtures in this analysis).

For Outdoor Sales Canopies, the Statewide CASE Team identified approximately 10,000 fueling stations in California,[10] and based on research of fuel stations has determined that virtually all of these will have a sales canopy below 24 feet. Based on the Statewide CASE Team research, about 65% of these (6,500) are 24-hour facilities, while the remaining 35% (3,500) are open from about 7:00 AM to 10:00 PM (on average). Again, the Statewide CASE Team estimates that 2% are new each year and 3% undergo major lighting retrofits, triggering code, and about half utilize higher wattage luminaires (122W in our analysis) and the other half low wattage luminaires (82W in our analysis).

For both Outdoor Sales Lots and Outdoor Sales Canopies, average statewide demand reduction was calculated by dividing the statewide energy savings by the number of hours per year during which our model evaluates potential savings for a 24-hour facility (3950 hours per year). The resultant average demand savings does not reflect the maximum demand savings and is not coincident with peak demand. In the final CASE Report, the Statewide CASE Team will re-evaluate whether there is any peak demand savings associated with this measure, given the 2016 TDV assumes the peak period has shifted relative to the assumed peak for the 2013 TDV.

4.7 Cost-effectiveness Methodology

This measure proposes a mandatory requirement. As such, a lifecycle cost analysis is required to demonstrate that the measure is cost-effective over the 15-year period of analysis.

CEC’s procedures for calculating lifecycle cost-effectiveness are documented in LCC Methodology (CEC 2014b). The Statewide CASE Team followed these guidelines when developing the Cost-effectiveness Analysis for this measure. CEC’s guidance dictated which costs were included in the analysis. Incremental equipment costs over the 15-year period of analysis were included. The TDV energy cost savings from electricity savings were considered. Each of these components is discussed in more detail below.

Design costs were not included nor were any incremental costs of verification.

[9] Taxable Sales in California 2012, California State Board of Equalization

[10] Retail Fuel Outlet Survey, California Energy Commission Energy Almanac

4.7.1 Incremental Cost Methodology

The Statewide CASE Team conducted outreach to manufacturers to obtain estimated incremental costs for compliance with this measure. There are multiple ways to set up occupancy based control systems, some of which are more costly than others. Circuit based controls are generally the least expensive on a per fixture basis, though per fixture costs will depend on the number of fixtures installed to the fixture. Fixture-integrated controls are usually slightly more expensive, while wireless mesh networks are significantly more expensive per fixture. Assuming an LED base case by 2017, and assuming controls included at time of primary LED fixture purchase, incremental cost of occupancy control systems are below.

Key assumptions used to derive cost are presented in Table 100.

Table 10: Key Assumptions for per unit Incremental Construction Cost

Parameter	Assumption	Source	Notes
Circuit-Based OCS	$60-$100/ fixture	Manufacturer Interviews	
Integrated OCS	$105/fixture	Manufacturer Interviews	
Wireless / Mesh OCS	$200/fixture	Manufacturer Interviews	

Incremental Construction Cost Methodology

As requested by CEC, the Statewide CASE Team estimated the Current Incremental Construction Costs and Post-adoption Incremental Construction Costs. The Current Incremental Construction Cost (ΔCI_C) represents the incremental cost of the measure if a building meeting the proposed standard were built today. The Post-adoption Incremental Construction Cost (ΔCI_{PA}) represents the anticipated cost assuming full market penetration of the measure as a result of the new Standards, resulting in possible reduction in unit costs as manufacturing practices improve over time and with increased production volume of qualifying products the year the Standard becomes effective. Some cost reductions may occur after adoption, as these technologies continue to develop and become more common. However, for the purposes of this analysis the team has not yet quantified the likely post-adoption incremental cost, and is using solely the current incremental cost in cost-effectiveness methodology.

Incremental Maintenance Cost Methodology

The Statewide CASE Team does not expect any incremental maintenance costs associated with this code change. If anything, dimming LED fixtures extends product life, so the consumer will see longer fixture life as a result of this measure in cases where LED lifetime limits fixture lifetime. The cost-effectiveness analysis currently does not take increased LED lifetime into account and is thus conservative in this respect. The Statewide CASE Team may update the cost-effectiveness analysis in the final report to account for decreased maintenance costs due to extended LED lifetimes.

4.7.2 Cost Savings Methodology

Energy Cost Savings Methodology

The present value of the energy savings were calculated using the method described in the LCC Methodology (CEC 2014b). In short, the hourly energy savings estimates for the first year of building operation were multiplied by the 2016 TDV cost values to arrive at the PV of the cost savings over the period of analysis. This measure is not climate sensitive, so the energy cost savings were calculated using an average of the TDV values for all climate zones.

Other Cost Savings Methodology

This measure does not have any non-energy cost savings.

4.7.3 Cost-effectiveness Methodology

The Statewide CASE Team calculated the cost-effectiveness using the LCC Methodology. According to CEC's definitions, a measure is cost effective if it reduces overall lifecycle cost from the current base case (existing conditions). The LCC Methodology clarifies that absolute lifecycle cost of the proposed measure does not need to be calculated. Rather, it is necessary to calculate the change in lifecycle cost from the existing conditions to the proposed conditions.

If the change in lifecycle cost is negative then the measure is cost effective, meaning that the present value of TDV energy savings is greater than the cost premium, or the proposed measure reduces the total lifecycle cost as compared to the existing conditions.

The Planning Benefit-to-Cost (B/C) Ratio is another metric that can be used to evaluate cost-effectiveness. The B/C Ratio is calculated by dividing the total present value TDV energy cost savings (the benefit) by the present value of the total incremental cost (the cost). If the B/C Ratio is greater than 1.0 (i.e. the present valued benefits are greater than the present valued costs over the period of analysis), then the measure is cost effective.

4.8 Environmental Impacts Methodology

4.8.1 Greenhouse Gas Emissions Impacts Methodology

Greenhouse Gas Emissions Impacts Methodology

The Statewide CASE Team calculated avoided GHG emissions assuming an emission factor of 353 metric tons of carbon dioxide equivalents ($MTCO_2e$) per GWh of electricity savings. As described in more detail in Appendix A, the electricity emission factor represents savings from avoided electricity generation and accounts for the GHG impacts if the state meets the Renewable Portfolio Standard (RPS) goal of 33 percent renewable electricity generation by 2020. Avoided GHG emissions from natural gas savings were calculated using an emission factor of 5,303 $MTCO_2e$/million therms (U.S. EPA 2011).

Greenhouse Gas Emissions Monetization Methodology

The 2016 TDV cost values include the monetary value of avoided GHG emissions, so the Cost-effectiveness Analysis presented in Section 5.2 of this report does include the cost savings from avoided GHG emissions. The monetization for the TDV values includes permit (retail) cost of avoided GHG emissions, but it does not include the social costs of avoided emissions. As evident in the results of the Cost-effectiveness Analysis, the value of avoided GHG emissions is aggregated into the total TDV cost savings and the contribution of GHG emissions is not easily discernible. To demonstrate the value of avoided GHG emissions, the Statewide CASE Team disaggregated the value of avoided GHG emissions from the overall TDV cost savings value. The Statewide CASE Team will include the monetary value of avoided GHG emissions in the final CASE Report.

4.8.2 Water Use and Water Quality Impacts Methodology

There are no impacts on water use or water quality resulting from this measure.

4.8.3 Material Impacts Methodology (Optional)

Material impacts were not calculated for this measure.

4.8.4 Other Impacts Methodology

No other impacts were quantified for this measure.

5. ANALYSIS AND RESULTS

Results from the energy, demand, cost, and environmental impacts analyses are presented in this section.

5.1 Energy Impacts Results

5.1.1 Per Unit Energy Impacts Results

Per unit energy and demand impacts of the proposed measure are presented in Table 11. Per unit savings for the first year are expected to range from 1,207 to 4,250 kilowatt-hours per year (kWh/yr), depending on facility type and scenario. These savings are based on a number of assumptions around system performance and occupancy patterns. Many of those assumptions were designed to demonstrate a conservative savings scenario. As more data is gathered by the Statewide CASE Team, some of these assumptions will be updated, and actual savings may be significantly higher.

It is estimated that the TDV electricity savings over the 15 year period of analysis will range from about 18,000 kBTU to about 80,000 kBTU. The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. Because this measure saves energy primarily at night (off peak), there are no peak savings attributed to this code change. Using the TDV method resulted in relatively low energy cost savings results compared to a measure that saves peak energy, based on the value given to peak energy in the TDV method.

Table 11: Energy Impacts per Prototype Facility[1]

Prototype	Fixture Wattage	Per Unit First Year Savings[2]			Per Unit First Year TDV Savings[3]	
		Electricity Savings[4] (kWh/yr)	Peak Demand Savings (kW)	Natural Gas Savings (Therms/yr)	TDV Electricity Savings[5] (kBTU)	TDV Natural Gas Savings[5] (kBTU)
Prototype 1: Large 24 Hr Sales Canopy	122W	4,039	NA	NA	67,036	NA
	82W	2,715	NA	NA	45,057	NA
Prototype 2: Large 15 Hr Sales Canopy	122W	4,250	NA	NA	46,145	NA
	82W	2,857	NA	NA	68,655	NA
Prototype 3: Small 24 Hr Sales Canopy	122W	1,795	NA	NA	29,794	NA
	82W	1,207	NA	NA	20,025	NA
Prototype 4: Small 15 Hr Sales Canopy	122W	1,889	NA	NA	20,509	NA
	82W	1,270	NA	NA	30,513	NA
Prototype 5: Corner Outdoor Sales Lot (12 Hrs)	202W	1,786	NA	NA	28,536	NA
	126W	1,114	NA	NA	17,800	NA

1. Savings are shown on a per prototype building basis
2. Savings from one prototype building for the first year the building is in operation.
3. TDV energy savings for one prototype building for the first year the building is in operation.
4. Site electricity savings. Does not include TDV of electricity savings.
5. Calculated using CEC's 2016 TDV factors and methodology. Includes savings from electricity.

5.1.2 Statewide Energy Impacts Results

First Year Statewide Energy Impacts

The statewide energy impacts of the proposed measure are presented in Table 12. During the first year buildings complying with the 2016 Title 24 Standards are in operation, the proposed measure is expected to reduce annual statewide electricity use by 1.62 GWh.

Table 12: Statewide Energy Impacts

	First Year Statewide Savings[1]			TDV Savings[2]	
	Electricity Savings[3] (GWh)	Power Demand Reduction (MW)	Natural Gas Savings (MMtherms)	TDV Electricity Savings[4] (Million kBTU)	TDV Natural Gas Savings[4] (Million kBTU)
Sales Canopies	1.24	NA	NA	20.4	NA
Sales Lots	0.38	NA	NA	6.0	NA
TOTAL	1.62			26.4	

1. First year savings from all buildings built statewide during the first year the 2016 Standards are in effect.
2. First year TDV savings from all buildings built statewide during the first year the 2016 Standards are in effect.
3. Site electricity savings.
4. Calculated using CEC's 2016 TDV factors and methodology.

All assumptions and calculations used to derive per unit and statewide energy and demand savings are presented in Section 4.4 of this report.

5.2 Cost-effectiveness Results

5.2.1 Incremental Cost Results

The incremental cost of the proposed measure, relative to existing conditions, is presented in Table 13. The total incremental cost includes the incremental cost during initial construction and the present value of the incremental maintenance cost over the 15-year period of analysis. Each of these components of the incremental cost is discussed below.

Table 13: Incremental Cost of Proposed Measure 2016 Present Value Dollars[1]

Condition	Incremental Initial Construction Cost		Incremental Present Value of Maintenance Cost[4]	Total Incremental Cost[5]
	Current[2]	Post Adoption[3]		
Incremental Measure Cost per Fixture	$105	$105	$0	$105
IMC Prototype 1 & 2	$3,780	$3,780	$0	$3,780
IMC Prototype 3 & 4	$1,680	$1,680	$0	$1,680
IMC Prototype 5	$1,050	$1,050	$0	$1,050

1. Incremental costs equal the difference between existing conditions and proposed conditions. Negative values indicate the Proposed Conditions are less expensive than Existing Conditions.
2. Initial construction cost using current prices; ΔCI_C
3. Initial construction cost using estimated prices after adoption; ΔCI_{PA}
4. Present value of maintenance costs over 15 year period of analysis; ΔCM.
5. Total costs equals incremental cost (post adoption) plus present value of maintenance costs; $\Delta CI_{PA} + \Delta CM$

Incremental Construction Cost Results

For the purposes of this analysis, the Statewide CASE Team has conservatively chosen the incremental cost for fixture-integrated controls ($105 per fixture) in order to show cost-effectiveness with fixture integrated controls, and circuit based controls which are estimated to be less expensive per fixture. The proposed measures may be significantly more cost effective if end users install lower cost circuit-based controls.

Incremental Maintenance Cost Results

The Statewide CASE Team does not expect any incremental maintenance costs associated with this code change. If anything, dimming LED fixtures extends product life, so there is some chance the consumer will see longer fixture life as a result of this measure.

5.2.2 Cost Savings Results

Energy Cost Savings Results

The per unit TDV energy cost savings over the 15-year period of analysis are presented in Table 14. The proposed measure results in cost savings in every climate zone (the measure is not climate specific) and in each of the prototype facilities developed.

As noted, this is a draft version of the CASE Report. The 2016 TDV values were not yet available when this draft report was being developed. The TDV energy and cost savings presented in this draft report were developed using 2013 TDV values and TDV cost saving are in 2011 dollars. The Statewide CASE Team will be submitting a revised version of this report in fall 2014, which will include the final recommended code change proposal and a updated TDV energy and cost savings results that use the 2016 TDV values.

Table 14: TDV Energy Cost Savings Over 15 Year Period of Analysis - Per Site

Prototype	Fixture Wattage	TDV Electricity Cost Savings	TDV Natural Gas Cost Savings	Total TDV Energy Cost Savings
		(2016 PV $)	(2016 PV $)	(2016 PV $)
Prototype 1: Large 24 Hr Sales Canopy	122W Fixtures	$5,966	NA	$5,966
	82W Fixtures	$4,010	NA	$4,010
Prototype 2: Large 15 Hr Sales Canopy	122W Fixtures	$6,110	NA	$6,110
	82W Fixtures	$4,107	NA	$4,107
Prototype 3: Small 24 Hr Sales Canopy	122W Fixtures	$2,652	NA	$2,652
	82W Fixtures	$1,782	NA	$1,782
Prototype 4: Small 15 Hr Sales Canopy	122W Fixtures	$2,716	NA	$2,716
	82W Fixtures	$1,825	NA	$1,825
Prototype 5: Corner Outdoor Sales Lot (12 hrs)	202W Fixtures	$2,540	NA	$2,540
	126W Fixtures	$1,584	NA	$1,584

Other Cost Savings Results

This measure does not have any non-energy cost savings.

5.2.3 Cost-effectiveness Results

Results per unit lifecycle Cost-effectiveness Analyses are presented in Table 15.

The proposed measure saves money over the 15-year period of analysis relative to the existing conditions. The proposed code change is cost-effective in each of the prototype space types modeled. As described in the methodology section, many of the assumptions that were made in the savings model and in the incremental cost analysis were conservative, in order to present a conservative assessment of cost-effectiveness. As more date becomes available, the actual cost-effectiveness analysis results may become even more favorable.

Table 15: Cost-effectiveness Summary[1]

Climate Zone	Fixture Wattage	Benefit: TDV Energy Cost Savings + Other Cost Savings[2] (2016 PV $)	Cost: Total Incremental Cost[3] (2016 PV $)	Change in Lifecycle Cost[4] (2016 PV $)	Benefit-to-Cost Ratio[5]
Prototype 1: Large 24-Hr Sales Canopy	122W Fixtures	$5,966	$3,780	($2,186)	1.6
	82W Fixtures	$4,010	$3,780	($230)	1.1
Prototype 2: Large 15-Hr Sales Canopy	122W Fixtures	$6,110	$3,780	($2,330)	1.6
	82W Fixtures	$4,107	$3,780	($327)	1.1
Prototype 3: Small 24-Hr Sales Canopy	122W Fixtures	$2,652	$1,680	($972)	1.6
	82W Fixtures	$1,782	$1,680	($102)	1.1
Prototype 4: Small 15-Hr Sales Canopy	122W Fixtures	$2,716	$1,680	($1,036)	1.6
	82W Fixtures	$1,825	$1,680	($145)	1.1
Prototype 5: Corner Outdoor 12-Hr Sales Lot	202W Fixtures	$2,540	$1,050	($1,490)	2.4
	126W Fixtures	$1,584	$1,050	($534)	1.5

1. Relative to existing conditions. All cost values presented in 2016 dollars.
2. Present value of TDV cost savings equals TDV electricity savings plus TDV natural gas savings; $\Delta TDV\$ = \Delta TDV\$E + \Delta TDV\$G$.
3. Total incremental cost equals incremental construction cost (post adoption) plus present value of incremental maintenance cost; $\Delta C = \Delta CI_{PA} + \Delta CM$.
4. Negative values indicate the measure is cost effective. Change in lifecycle cost equals cost premium minus TDV energy cost savings; $\Delta LCC = \Delta C - \Delta TDV\$$
5. The Benefit-to-Cost Ratio is the TDV energy costs savings divided by the total incremental costs; $B/C = \Delta TDV\$ \div \Delta C$. The measure is cost effective if the B/C ratio is greater than 1.0.

5.3 Environmental Impacts Results

5.3.1 Greenhouse Gas Emissions Results

Table 16 presents the estimated first year avoided GHG emissions of the proposed code change. During the first year the 2016 Standards are in effect. The monetary value of avoided carbon emissions will be presented in the next version of this report. The monetary value of avoided GHG emissions is included in TDV cost factors (TDV $) for each hour of the year and thus included in the Cost-effectiveness Analysis presented in this report.

Table 16: Statewide Greenhouse Gas Emissions Impacts

	First Year Statewide	
	Avoided GHG Emissions[1] ($MTCO_2e$/yr)	**Monetary Value of Avoided GHG Emissions[2] ($2016)**
Sales Canopies	438	TBD
Sales Lots	134	TBD
TOTAL	572	TBD

1. First year savings from buildings built in 2017; assumes 353 $MTCO_2e$/GWh and 5,303 $MTCO_2e$/MMTherms.
2. Monetary value of carbon is included in cost-effectiveness analysis; assumes {TBD}$/ $MTCO_2e$.

5.3.2 Water Use and Water Quality Impacts

There are no projected impacts on water use or water quality, as shown in Table 17.

Table 17: Impacts of Water Use and Water Quality

			Impact on Water Quality Material Increase (I), Decrease (D), or No Change (NC) compared to existing conditions			
	On-Site Water Savings[1] (gallons/yr)	**Embedded Energy Savings[2] (kWh/yr)**	**Mineralization (calcium, boron, and salts)**	**Algae or Bacterial Buildup**	**Corrosives as a Result of PH Change**	**Others**
Impact (I, D, or NC)	NC	NC	NC	NC	NC	NC
Per Unit Impacts	N/A	N/A	N/A	N/A	N/A	N/A
Statewide Impacts (first year)	N/A	N/A	N/A	N/A	N/A	N/A
Comment on reasons for your impact assessment	N/A	N/A	N/A	N/A	N/A	N/A

1. Does not include water savings at power plant
2. Assumes embedded energy factor of 10,045 kWh per million gallons of water.

5.3.3 Material Impacts Results (Optional)

The impacts of the proposed code change on material use were not evaluated.

5.3.4 Other Impacts Results

Occupancy-based controls offer a potential safety feature of drawing attention to the arrival of an occupant to the space in the middle of the night. Also, operating LED fixtures in dimmed states for a significant amount of time is likely to extend the product lifetime.

6. PROPOSED LANGUAGE

The proposed changes to the Standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2013 documents are marked with underlining (new language) and ~~strikethroughs~~ (deletions).

6.1 Standards

(c) **Controls for Outdoor Lighting.** Outdoor lighting controls shall be installed that meet the following requirements as applicable:

> **EXCEPTION 1 to Section 130.2(c):** Outdoor lighting not permitted by a health or life safety statute, ordinance, or regulation to be turned OFF.
>
> **EXCEPTION 2 to Section 130.2(c):** Lighting in tunnels required to be illuminated 24 hours per day and 365 days per year.

1. All installed outdoor lighting shall be controlled by a photocontrol or outdoor astronomical time-switch control that automatically turns OFF the outdoor lighting when daylight is available.

2. All installed outdoor lighting shall be circuited and independently controlled from other electrical loads by an automatic scheduling control.

3. All installed outdoor lighting, where the bottom of the luminaire is mounted 24 feet or less above the ground, shall be controlled with automatic lighting controls that meet all of the following requirements:

   A. Shall be motion sensors or other lighting control systems that automatically controls lighting in accordance with item B in response to the area being vacated of occupants; and

   B. Shall be capable of automatically reducing the lighting power of each luminaire by at least 40 percent but not exceeding ~~80~~ 90 percent, or provide continuous dimming through a range that includes 40 percent through ~~80~~ 90 percent, and

   C. Shall employ auto-ON functionality when the area becomes occupied; and

   D. No more than 1,500 watts of lighting power shall be controlled together.

   EXCEPTION 1 to Section 130.2(c)3: Lighting for Outdoor Sales Frontage~~, Outdoor Sales Lots, and Outdoor Sales Canopies~~ complying with Section 130.2(c)4.

   EXCEPTION 2 to Section 130.2(c)3: Lighting for Building Facades, Ornamental Hardscape and Outdoor Dining complying with Section 130.2(c)5.

   EXCEPTION 3to Section 130.2(c)3:, Outdoor lighting, where luminaire rated wattage is determined in accordance with Section 130.0(c), and which meet one of the following conditions:

      A. Pole-mounted luminaires each with a maximum rated wattage of ~~75~~ 30 watts; or

      B. Non-pole mounted luminaires with a maximum rated wattage of 30 watts each; or

      C. Linear lighting with a maximum wattage of 4 watts per linear foot of luminaire.

EXCEPTION 4 to Section 130.2(c)3: Applications listed as Exceptions to Section 140.7(a) shall not be required to meet the requirements of Section 130.2(c)3.

4. For Outdoor Sales Frontage~~, Outdoor Sales Lots, and Outdoor Sales Canopies~~ lighting, an automatic lighting control shall be installed that meets the following requirements:

A. A part-night outdoor lighting control as defined in Section 100.1; or

B. Motion sensors capable of automatically reducing lighting power by at least 40 percent but not exceeding ~~80~~ 90 percent, and which have auto-ON functionality.

6.2 Reference Appendices

There are no proposed changes to the Reference Appendices.

6.3 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual

6.4 Compliance Manuals

Chapter 6 of the Nonresidential Compliance Manual will need to be revised slightly to explain that Sales Canopies and Sales Lots are no longer exempted from the occupancy based multi-level control requirement.

6.5 Compliance Forms

Forms NRCC-LTO-02-E: Certificate of Compliance: Outdoor Lighting Controls, may need to be revised slightly to reflect the application of code requirements to additional space types.

7. References and Other Research

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Appendix A: Environmental Impacts Methodology

Greenhouse Gas Emissions Impacts Methodology

The avoided GHG emissions were calculated assuming an emission factor of 353 metric tons of carbon dioxide equivalents ($MTCO_2e$) per GWh of electricity savings. The Statewide CASE Team calculated air quality impacts associated with the electricity savings from the proposed measure using emission factors that indicate emissions per GWh of electricity generated.[11] When evaluating the impact of increasing the Renewable Portfolio Standard (RPS) from 20 percent renewables by 2020 to 33 percent renewables by 2020, California Air Resources Board (CARB) published data on expected air pollution emissions for various future electricity generation scenarios (CARB 2010). The Statewide CASE Team used data from CARB's analysis to inform the air quality analysis presented in this report.

The GHG emissions factor is a projection for 2020 assuming the state will meet the 33 percent RPS goal. CARB calculated the emissions for two scenarios: (1) a high load scenario in which load continues at the same rate; and (2) a low load rate that assumes the state will successfully implement energy efficiency strategies outlined in the AB32 scoping plan thereby reducing overall electricity load in the state.

To be conservative, the Statewide CASE Team calculated the emissions factors of the incremental electricity between the low and high load scenarios. These emission factors are intended to provide a benchmark of emission reductions attributable to energy efficiency measures that could help achieve the low load scenario. The incremental emissions were calculated by dividing the difference between California emissions in the high and low generation forecasts by the difference between total electricity generated in those two scenarios. While emission rates may change over time, 2020 was considered a representative year for this measure.

Avoided GHG emissions from natural gas savings were calculated using an emission factor of 5,303 $MTCO_2e$/million therms (U.S. EPA 2011).

Greenhouse Gas Emissions Monetization Methodology

The 2016 TDV cost values used in the LCC Methodology includes the monetary value of avoided GHG emissions based on a proxy for permit costs (not social costs) and the Cost-effectiveness Analysis presented in Section 5.2 of this report does include the cost savings from avoided GHG emissions. To demonstrate the cost savings of avoided GHG emissions, the Statewide CASE Team disaggregated value of avoided GHG emissions from the other economic impacts. The Statewide CASE Team used the same monetary values that are used in the TDV factors – \${TBD}/$MTCO_2e$.

[11] California power plants are subject to a GHG cap and trade program and linked offset programs until 2020 and potentially beyond.

Water Use and Water Quality Impacts Methodology

There are no impacts on water use and water quality for the proposed measure.

Appendix B: Job Creation by Industry

Table 18 shows total job creation by industry that is expected from all investments in California energy efficiency and renewable energy (UC Berkeley 2010, Appendix D). While it is not specific to codes and standards, this data indicates the industries that generally will receive the greatest job growth from energy efficiency programs.

Table 18: Job Creation by Industry

NAICS	Industry Description	Direct Jobs	
		2015	2020
23822	Plumbing, Heating, and Air-Conditioning Contractors	8,695	13,243
2361	Residential Building Construction	5,072	7,104
2362	Nonresidential Building Construction	5,345	6,922
5611	Office Administrative Services	2,848	4,785
23821	Electrical Contractors	3,375	4,705
551114	Corporate, Subsidiary, and Regional Managing Offices	1,794	3,014
54133	Engineering Services	1,644	2,825
5418	Advertising and Related Services	1,232	2,070
334413	Semiconductor and Related Device Manufacturing	1,598	1,598
541690	Other Scientific and Technical Consulting Services	796	1,382
23831	Drywall and Insulation Contractors	943	1,331
3334	Ventilation, Heating, Air-Conditioning, & Commercial Refrigeration Equip. Manf.	453	792
3351	Electric Lighting Equipment Manufacturing	351	613
926130	Regulation and Administration of Communications, Electric, Gas, Other Utilities	322	319
23816	Roofing Contractors	275	277
54162	Environmental Consulting Services	151	261
484210	Used Household and Office Goods Moving	137	239
23835	Finish Carpentry Contractors	120	120
23829	Other Building Equipment Contractors	119	113
3352	Household Appliance Manufacturing	63	110
other	Other	454	547
	Total	**35,788**	**52,369**